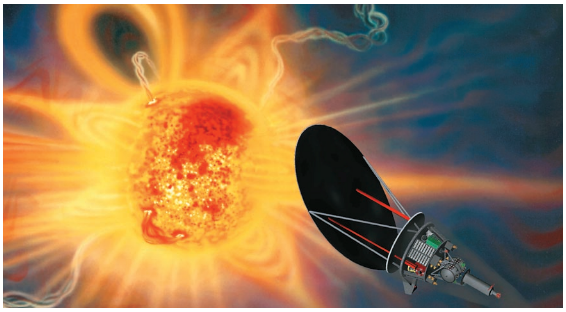
CAREERS IN PHYSICS

Not Even the Sky's the Limit!

When a signal leaves a satellite or interplanetary space probe, a special code is embedded in it to give it a time-stamp. When the signal is picked up on Earth, that time-stamp is compared to a terrestrial clock. Subtracting the two gives the travel time between the satellite or space probe and the ground station. Since the signal travels at the speed of light, all you should need to do then is multiply the time by *c* to determine the distance — but it's not that simple.



Gravity is part of the problem. According to Einstein's general theory of relativity, clocks run more slowly in a gravitational field. The stronger the field is, the slower the clocks run. Clocks on board spacecraft and satellites run slightly faster in interplanetary space than they do near Earth. These timing differences result in distance measurement differences between what is observed from a ground station and from a spacecraft. The situation becomes even more complicated as the spacecraft dips into and out of the gravitational fields of planets that it encounters on its voyage.

A second problem results from the relative velocity between the spacecraft and the ground station. Einstein's special theory of relativity, discussed in detail in this chapter, describes how time intervals and distance measurements vary between inertial frames of reference that are in motion relative to each other. This relative velocity is continually changing as a result of the gravity of the Sun and planets and due to Earth's orbital and rotational velocities. Relativistic corrections — numerical adjustments based on the theory of relativity — are an ongoing challenge in spacecraft instrument design.

There are "a whole suite of careers that utilize these things," Steve Lichten, manager of the Tracking Systems and Applications Section of NASA's Jet Propulsion Laboratory, says of relativity. Einsteinian physics is no longer the sole property of university researchers. Commercial satellite manufacturers must have an understanding of relativity in order for their products to work.

Theoreticians, engineers, and computer scientists must work together to help a spacecraft communicate with its ground station, so the companies that manufacture spacecraft and commercial satellites are always on the lookout for people with the necessary knowledge. Generally, an advanced graduate degree in engineering, physics, or mathematics is preferred, although a bachelor's degree in science with a demonstrated understanding of the concepts and techniques involved will go a long way.

So brush up your math skills and keep doing those thought experiments. Some day, they might take you to the stars!

Going Further

1. Describe some examples of satellites that require extremely precise distance and time measurements. Explain why such precision is necessary for those satellites.
2. Many companies that manufacture satellites or equipment for use on satellites (including space stations) offer summer internship programs for interested students. Find out if any of these companies are located near you and call them. You might be able to get a head start on a great career!
3. Research the space probes, such as the one shown in the photograph, that are currently active. Explain why precise knowledge of time intervals and distances is of extreme importance to the operation of space probes.

WEB LINK

www.mcgrawhill.ca/links/physics12

For information about the NASA Jet Propulsion Laboratory's past, current, and planned space missions, go to the above Internet site and click on **Web Links**.